

# RETHINKING THE TIN MOUNTAINS: PATTERNS OF USAGE AND CIRCULATION OF TIN IN GREATER IRAN FROM THE 4TH TO THE 1ST MILLENNIUM BC

## KALAY MADENİ OLAN DAĞLAR HAKKINDA YENİ YAKLAŞIMLAR: MÖ 4 – 1. BİNYILDA İRAN GENELİNDE KALAYIN KULLANIM VE DOLAŞIMI

Barbara HELWING

**Keywords:** Iran, tin, Bronze Age, tin alloy, metal trade

**Anahtar Sözcükler:** İran, kalay, Tunç Çağ, kalay alaşımı, metal ticareti

### ÖZET

*İran'da bakır ve kalay yataklarının bulunduğu yüksek kesimler ile, Mezopotamya'nın ilk kent devletlerinin ve özellikle bunların gelişen endüstrileri arasında yakın bir ilişki olduğu uzun yıllardan bu yana öngörülmekteydi. Sümer metinleri MÖ 3. binyıldan itibaren Mezopotamya'ya kalayının geliş yeri olarak İran'ın güney kesimlerine atıfta bulunmaları da bu yargıya varılmasına neden olmuştur. Buna rağmen bu yüksek düzlüklerde yakın zamana değin uygun niteliklere sahip eski kalay işletmelerine rastlanamamıştır. İran'ın orta ve doğu bölgelerinde gelişmekte olan ve uzun mesafeli ticarete yer alan kent devletlerin de kalayı bilinçli olarak kullanmadıkları bilinmekteydi. Ancak son yıllarda yapılan araştırmalar Zagroslar'da daha önceden bilinmeyen kalay, bakır ve altın madenlerinin varlığını ortaya çıkarmıştır. Yeni araştırmalar ışığında ve gelişen analiz yöntemleri ile bu maden yataklarının MÖ 3. binyılın başlarından itibaren yerel olarak kullanıldığı belirlenmiştir. Böylece tunç üretiminde kullanılan ve özellikle ünlü Luristan tunç aletleri için gerekli kalayın geliş kaynağı açısından yeni seçenekler ortaya çıkmış bulunmaktadır.*

### INTRODUCTION

The appearance of tin as the second major alloying partner of copper to produce bronze is regarded as one of the markers of the beginning of the Bronze Age in most parts of the Old World. This applies as well to Southwestern Asia, where bronze, and henceforth tin, is widely used since the later 3<sup>rd</sup> millennium BC in the nascent states of Mesopotamia. The sources that supplied Mesopotamian metal industry with tin remain elusive, however, no adequate sources

for tin were known in the wider region and the question for the origin of this tin remained a controversially debated one in archaeometallurgical research. Sumerian texts of the late 3<sup>rd</sup> millennium position the origin of this metal somewhere east of Mesopotamia, so that Iran and its neighbouring countries figure as possible candidate to supply tin to Mesopotamia. From the point of view of metallo-genesis, the nearest tin sources east of Mesopotamia can be expect-

ed in Eastern Iran and Afghanistan, where indeed tin deposits are attested. The sheer geographic distance between these possible sources and the consumers in Mesopotamia is puzzling but can be overcome through organized long distance trade. Models on long distance procurement of tin (Stech and Pigott 1986) have therefore found wide acceptance and are corroborated through recent findings of possible intermediaries of the maritime trade via the Persian Gulf (Weeks 2003).

The incentive to review the debate on ancient tin from the lands east of Mesopotamia (Fig. 1) is due to the impact of several new sets of data that add considerable detail to our knowledge. The recent discovery of tin sources such as the mining area of Deh Hossein in the Iranian Central Zagros (Nezafati *et al.* 2006), that was possibly exploited in antiquity, considerably alters our map of source areas. Likewise, ongoing programs of archaeometallurgical analyses<sup>1</sup> with regard to artefact composition and provenience provide important detailed information.

The following paper aims at a review of the archaeological evidence surrounding the question of exploitation and usage of tin in ancient Iran from the beginning until the Early Iron Age<sup>2</sup>, in order to determine models of usage, alloying practice and consumption, with a specific focus on recent research that has considerably altered our understanding of the usage of tin in ancient Iran. Among the issues discussed are; (1) the location of raw material sources east of Mesopotamia; (2) the beginning of the use of tin in Iran and its neighbourhood; (3) the uneven distribution and the apparent “technological conservatism” in the central Iranian highlands in contrast to the assumed trade networks that made eastern tin available to Mesopotamian bronze working centres; (4) the procurement of tin for the usage in the famous Lorestan bronzes. In conclusion, this evidence will be discussed within the wider context of historical and cross-cultural relations.

## BACKGROUND: TEXTUAL EVIDENCE FOR THE USE OF TIN AND TIN ALLOYS

The first tin alloys appear in Mesopotamian metal working sometime at the beginning of the 3<sup>rd</sup> millennium BC, although as singular specimen and not all of them beyond doubt with regard to find context and circumstances.<sup>3</sup> Textual sources, by contrast,

refer for the first time to the regular use of tin bronze and its deliberate distinction from copper only in Sumerian texts dating to the Ur I period (Moorey 1994: 298). Indeed, this correlates in time with the first archaeological evidence for the systematic large scale usage of bronze in the ED IIIa period, for example in the famous cemetery at Ur and in other burial assemblages of the late ED period<sup>4</sup>. Metallic tin is equally used since the same time, either as a solder material or as a coating for copper vessels (Moorey 1994: 297). Texts from the Ebla archives, written at about the same time, refer to recipes and standard mixtures of copper and tin for the production of spearheads and other weapons (Van Lerberghe 1988; Waetzold 1993), indicating that by the mid 3<sup>rd</sup> millennium BC, the use of tin was an established practice in the production of metal artefacts, and was most probably to a large extent controlled by the central authorities. Such a standard usage of a material as of the mid 3<sup>rd</sup> millennium BC in Mesopotamia is only possible if a reliable and accessible source for the procurement of this material can be located.

According to the textual sources there are two major areas renowned for the occurrence of tin: one area refers to countries in the Iranian highlands, some of them explicitly named while often less specifically only “tin mountains” are mentioned, an area that cannot be verified; the second are lands in the Persian Gulf area, specifically the island Dilmun and the land of Meluhha. These latter seem to have functioned not as a source region but as an intermediary of long distance trade since the later 3<sup>rd</sup> millennium BC and are attested as suppliers of tin in the texts from the Ebla archives and in texts from Gudea (Moorey 1994: 298).

In the Iranian highlands, epic texts mention the lands of Aratta whose soil is said to have consisted of “tin stone”. Tempting as it is, Aratta must be excluded as a possible source of tin: the name Aratta seems not to refer to a real land, but rather to a mental concept of “a land of plenty”, including tin<sup>5</sup>. A second source area reported in the Iranian highlands are the lands of Zabshali/Shimashki in the Southern Zagros<sup>6</sup>, commemorated for a rich booty of tin by the Ur III king Shusin, and the lands of Anshan, to be equated with the modern site Tal-e Malyan and its hinterland, in highland Fars. Anshan, and further west Susa, are actually known as on the road stations for donkey car-

avans that reached to Mari on the Middle Euphrates via Eshnunna and the Diyala valley (Joannès 1991). According to the Mari archive texts, these caravans were run by agents with Elamite names and transported tin ingots of a standard weight (Moorey 1994: 298, Potts 1999: table 6.2).

### ISSUE 1: SOURCES OF TIN IN THE EAST

Scholars who had been aware of the textual evidence referring to tin sources in the highlands east of Mesopotamia<sup>7</sup> have undertaken various attempts to locate deposits of tin ores. Reports by the medieval Arabian geographers Moghaddasi and Mostofi on the existence of tin sources in the area of Hamadan and Lorestan in the Central Zagros could not be verified by Theodore Wertime who worked in that area in the 1960s (Muhly 1973). Northwest Iran, specifically the Lake Orumiye neighbourhood close to Tabriz and the estuary mouth of the Sefidrud to the Caspian Sea, have been claimed also as sources for tin (Muhly 1973). Again, the Geological Service of Iran could not verify the existence of tin deposits neither in Tabriz or the Orumiye Lake area, nor on the Sefidrud. The only claim that seems to hold, albeit sparsely, is Strabo's (XV 2, 10) mention of ancient Drangiana, modern Sistan, where the Geological Service reports the tin deposits from Chah Kalapi, Shahkuh and Chah Ruh (Vatandoust 1999: 123 map fig. 2). The Sistan sites form part of a larger area with sparse tin occurrences in the Hilmand basin that extends further east and northeast until the area of Herat in western Afghanistan (Stech and Pigott 1986: 44-45). It is only beyond this zone that considerable tin deposits are known to have existed: well known are the tin mineralizations in the Kandahar – Badakhshan area (Stech and Pigott 1986: 44). Equally long known are tin mines in the Zarafshan Valley in Usbekistan/Kasakhstan that were only recently excavated and seem to have been in use since the later 3<sup>rd</sup> or early 2<sup>nd</sup> millennium BC (Parzinger and Boroffka 2003).

Such a distribution of tin sources in the extreme East of Iran, in Afghanistan and the Zarafshan Valley seems to indicate that highland Iran could at no time have functioned as a direct supplier of tin to the Mesopotamian states. Instead, mention of tin from the towns in highland South Iran in the Ur III texts and later-on could be related to the status of these towns as intermediaries, channelling the trade of

tin from the sources located even further east.

### RE-THINKING TIN SOURCES IN IRAN

This seemingly clear-cut pattern – sources in East Iran and Afghanistan – controlled trade in tin via South Iran – processing and consumption in Mesopotamia/and adjacent countries of Khuzestan and Lorestan is now at stake against the considerable evidence that has more recently become available.

While it was never categorically excluded and remains a possibility on the grounds of its geological setting (Muhly 1973: 260-261), evidence for the existence of tin sources in Iran, except for Sistan, is generally weak (Wertime 1978: 3). Likewise, tin was not mined or used systematically in the medieval or more recent periods (Moorey 1994: 299). However, as M. Momenzadeh has recently pointed out, specific associations with tin can occur in polymetallic deposits together with copper, wolfram and gold (Momenzadeh 2004: 13; Nezafati *et al.* 2008: 86). Such deposits may in ancient times have been exploited as sources for gold or copper, with no immediate attention to tin. The metallogenetic conditions in some areas of Iran are such that the existence of Cu-Sn-W-Au-deposits can indeed be assumed. He points at four areas where such conditions can be observed: one is the middle part of the Sanandaj-Sirjan-Belt in the Zagros, where the recently recognized mining area of Deh Hossein (Nezafati *et al.* 2006; Nezafati *et al.* 2008) is located. The site has ample evidence for ancient mining, latest from the 1<sup>st</sup> millennium BC onwards, although the date of its most ancient exploitation is difficult to determine.

### ISSUE 2: THE EARLY USE OF TIN IN IRAN – EVIDENCE FROM ARTEFACTS

In Southwestern Asia, the earliest artefacts produced from copper-tin alloys date to the 4<sup>th</sup> and early 3<sup>rd</sup> millennium. Since the beginning of the Bronze Age in the Old World is *per definition* linked to the occurrence of tin bronze in the archaeological record,<sup>8</sup> the appearance of the earliest tin-copper alloys has always been regarded with special scrutiny. None of the canonized pre-3<sup>rd</sup> millennium bronzes holds up against close examination. Often, stratigraphic evidence for the dating of the objects is unreliable, or objects analysed long ago are not available for re-analysis.<sup>9</sup> Early 3<sup>rd</sup> millennium

BC copper-tin alloys, however, were recorded in a more reliable way as singular objects or small groups from various areas at wide distance from each other.<sup>10</sup> Often, the amount of tin included is small, and the objects may be the result of the smelting of polymetallic ores rather than a deliberate production of an alloy (Nezafati 2006: 77).

The use of copper-tin alloys in the first half of the 3<sup>rd</sup> millennium was established through analyses on material from elite burials in the Y cemetery in Kish (Stech 1988; 1999; Müller-Karpe 1989: 184; 2004: no. 752; Lutz and Pernicka 2004: no. 752). To this early material can be added samples from Abu Salabikh (Lutz and Pernicka 2004: no. 8, 10, 18; Müller-Karpe 2004: no. 8, 10, 18), Tell Razuk (Lutz and Pernicka 2004: no. 723, Müller-Karpe 2004: no. 723), and a metal curl probably from a statue from Tell Agrab (Lutz and Pernicka 2004: no. 45; Müller-Karpe 2004: no. 45; see fig. 2). Along the Middle Euphrates, copper-tin alloys have recently been brought to light in a chamber tomb of the EBA I period in Qara Quzaq (Montero Fenollós 1995, Montero 1997: 16 fig. 1, Montero Fenollós 2000).

New finds of early copper-tin alloys are also recorded for the Caucasus from a multiple burial in Velikent/Daghestan (Kohl 2002) and from a burial mound in Talin in Armenia (Meliksetiyan *et al.* 2003).

Results from chemical analyses recently carried out on material from Lorestan now add considerable to this picture of emerging copper-tin-alloying in the early 3<sup>rd</sup> millennium BC. The burials from area AI in Kalleh Nisar, excavated by Louis Vanden Berghe in the 1960s, yielded some decorative items (2 finger rings, 2 bracelets, 1 pin) that all contained at least 3.5% tin and are considered deliberate alloys (Fleming *et al.* 2005: 36-37, 47 tab. 1). They date to the EB I period in Lorestan, contemporary with the Jamdat Nasr to ED I period in Mesopotamia. Properly speaking, the tin-copper alloys attested in the Kalleh Nisar AI tombs are among the earliest evidence for the use of tin as an alloying material in Southwestern Asia.

The Kalleh Nisar tombs are located in close geographic proximity to the recently discovered tin deposits from Deh Hossein. Although not attested yet for this early period,<sup>11</sup> it cannot be excluded that such tin sources were exploited earlier in antiquity as part of experimenting with polymetallic ores

as suggested above. Isotope analyses indicate that ores from Deh Hossein could indeed have been used for the production of some of the Lorestan bronzes sampled by N. Nezafati and F. Begemann/S. Schmitt-Strecker (Nezafati 2006: tab. 7.4; Nezafati *et al.* 2008: 84-87 fig. 5; Begemann *et al.* 2008: 29). All sampled artefacts date to a period later in the 3<sup>rd</sup> millennium BC though.

This thought can be developed further: given the distribution of the few early copper-tin alloys in Northern Mesopotamia (listed above), especially in Kish, Razuk and Agrab, it is tempting to link these isolated occurrences<sup>12</sup> with the experimental exploitation of localized tin occurrences such as Deh Hossein. Kish, indeed one of the paramount urban centers and, according to the Sumerian king list, the seat of the dynasty of Kish during the earlier ED period, may have had access to such sources in the mountains at that time.

The Qara Quzaq EB I group of tin bronzes (listed above) may be indicative of a similar phenomenon. Isotope analyses for this material have not been carried out so far; it is tempting, however, to suggest the possibility that another small scale local source may have been exploited for this production.

## THE INTRODUCTION OF TIN BRONZES IN WESTERN IRAN

Area C on the site of Kalleh Nisar yielded several corridor graves with subsequent multiple burials dating from the earlier part of the 3<sup>rd</sup> millennium BC until around 2400 BC. Chemical analyses of this material yielded 15 out of 19 sampled artefacts in tin bronze (Fleming *et al.*, 2005: 37, 47 tab. 2), thus indicating a more standardized and regular use of this material. Such a development would closely reflect developments that are observed in the lowlands of Khuzestan, where tin bronzes appear in Susa since period IVb and become a common material only in period V, around the turn towards the 2<sup>nd</sup> millennium BC (Malfoy and Menu 1987: 360-362 tab. D). This development is not shared in Lorestan, however. Towards the end of the EBA, that is, during the last two centuries of the 3<sup>rd</sup> millennium BC, represented by single tombs in Kalleh Nisar area AII, there is a sharp drop in the amount of tin bronze in the burials: only four out of 13 sampled artefacts contain significant amounts of tin (Fleming *et al.*, 2005: 38, 48 tab. 3).



In conclusion, evidence on the early use of tin alloys in western Iran reveals an interesting pattern: a period of early usage of ores containing tin, possibly of local origin is attested. The exploitation of these sources correlates in time with the appearance of isolated finds of copper-tin alloys in elite burials in the Hamrin and the Mesopotamian alluvium. This pattern may indicate a period of experimenting with new materials such as polymetallic ores, possibly not even with the aim to obtain tin bronze, but a search for optically and technologically attractive materials. Whether this very raw material is used throughout the following centuries remains unknown and deserves further analytical scrutiny with regard to provenience. It is well possible that with the integration of parts of Western Iran into the realm of the expanding empires of Akkad and Ur III, local production ceased. Trade in bulk metals would then have come under closer control of the lowland state, with a distribution organized via central agencies in the urban centres. Naturally, the swaying of political circumstances may then be reflected in the reliability of metal supply also to the highlands. The lack of tin bronze in the Western Iranian highlands during the final centuries of the 3<sup>rd</sup> millennium BC would in such a scenario underline the growing dependency on central authorities.

### ISSUE 3: THE LACK OF TIN IN SITES OF THE CENTRAL AND EASTERN IRANIAN HIGHLANDS AND THE LATE ADOPTION OF TIN USE

In contrast to western Iran, tin bronze was hardly used in eastern and southeastern Iran before the 2<sup>nd</sup> millennium BC. Even further east and hence closer to the tin sources in Afghanistan are only a few isolated finds from the 4<sup>th</sup> and 3<sup>rd</sup> millennium BC recorded, none of them beyond doubt.<sup>13</sup> Solely the 3<sup>rd</sup> millennium BC Indus culture again used tin bronzes to a considerable extent (Kenoyer and Miller 1999).

Sites in eastern Iran, including the large urban centers of Shahr-e Sukhte (Hauptmann 1980, Hauptmann *et al.* 2003; Artioli *et al.* 2005) and Shahdad (Hakemi 1997), hardly yielded any tin alloys from the 3<sup>rd</sup> millennium BC, and the few bronzes that occur are considered imports (Tallon 1987: 335). Also, people in Tappe Hesar, another urban size site further west on the northern edge of the Central Iranian desert, apparently did not make use of tin (Pigott 1989: 32). Only at Tappe Yahya is tin sporadically

attested since period IVB, resp. in the last third of the 3<sup>rd</sup> millennium BC (Thornton *et al.* 2002; Thornton *et al.* 2005). Tal-e Malyan, ancient Anshan, is besides Yahya the only site where tin bronze is in regular use since the late 3<sup>rd</sup>/early 2<sup>nd</sup> millennium BC Kaftari phase (Pigott 2004: 34).

A review of 3<sup>rd</sup> millennium BC sites around the Central and East Iranian desert reveals that the apparent “void” in the use of tin may be exaggerated through the general problem of site recognition in this part of the country throughout the 3<sup>rd</sup> millennium BC. Major sites are abandoned at the end of the Protoelamite period, that is, sometime during the first half of the 3<sup>rd</sup> millennium BC,<sup>14</sup> and there is hardly any evidence for continuous occupation. Various models to understand this site distribution pattern have been brought forward, including environmental constraints and related shifts towards a more mobile and archaeologically less visible lifestyle (Sumner 1989). However, sound explanations for this pattern will have to await further fieldwork with regard to site detectibility, possible sedimentation coverage and other problems.<sup>15</sup>

Despite this bias obvious in the archaeological data, a pattern of “avoidance” of tin uses in 3<sup>rd</sup> millennium BC East and Central Iran can still be stated. This is even the more surprising since the circum desert towns of Eastern and Central Iran seem to have actively engaged in trafficking various kinds of raw materials over long distances. Trade in stone vessels made from chlorite and alabaster, in semiprecious stones like lapis lazuli and cornelian, but probably also in other materials seems to have been of major importance throughout the 3<sup>rd</sup> millennium BC.<sup>16</sup> Many models on the tin trade link it to the trade in other precious and prestigious materials with restricted and known proveniences (Herrmann 1964; Crawford 1974; Stech and Pigott 1986), especially with gold and lapislazuli that abound in 3<sup>rd</sup> millennium BC elite burials in Mesopotamia. While such stone materials are indeed richly attested in Eastern and Central Iran burial sites, copper and possibly tin that could have travelled alongside these are not attested in the same contexts. Obviously, tin did not yet enter the general circulation of goods then (Stech 1999: 64; Muhly and Stech 2003: 423). This puzzling pattern has propelled various explanatory models.

One possibility aims at the recognition of long distance trade relations for the 3<sup>rd</sup> millennium BC that would have run under the tight control of central authorities in Mesopotamia, respectively their agents. The lack of tin bronze in the towns close to the source areas can then be judged as indicative of a restricted access to this raw material.<sup>17</sup> Only Elam in Southern Iran that was over periods included in the political sphere of the Akkad and the Ur III Empire would have participated in this trade network and would thus have received tin via maritime trade on the Persian Gulf for further distribution towards Mesopotamia and the Elamite hinterland.

A different model proposed first by T. Stech and V. Pigott (Stech and Pigott 1986; lastly: Pigott 2004: 30) suggests a deliberate “technological conservatism” evident in the Southeast Iranian 3<sup>rd</sup> millennium BC towns. Communities in this area, where arsenic-copper alloys were amply used since the early 4<sup>th</sup> millennium BC, may not have felt any need to change their craft traditions. According to this model, a culturally conditioned choice is obvious behind the decision to not adopt tin alloy technologies in these sites. Results from a program on further analysis recently run on the basis of materials from Tappe Yahya (Thornton *et al.* 2002; Thornton *et al.* 2005) is interpreted to corroborate the validity of the pattern of deliberate non-adoption of tin use as a matter of cultural choice: in Yahya IVB (2400-2000 BC), earliest alloys with traces of tin occur, but still in period IVA (2000-1700 BC) only five out of 34 copper base objects can be considered tin bronzes (all data according to Thornton *et al.* 2005). The usage of tin bronze in Yahya is established on a regular base only from the 17<sup>th</sup> century BC onwards and is assigned variously to impacts from Central Asian cultures where the availability of tin from the Zarafshan valley sources would have fuelled the development of a tin bronze metallurgy there that would have reflected upon the eastern Iranian cultures.<sup>18</sup>

Whether the choice against the use of tin bronze in the Eastern and Central Iranian sites is motivated by a “cultural choice” against a material that is based on reasoning such as function, aesthetics or else, remains unknown. However, a scenario that, instead of advocating a “cultural choice”, considers obstacles that exclude the communities of the Iranian towns from participating in the circulation of the necessary raw materials, through political measures such as

restrictions on access, restricted trade relations or other possibilities, is probably more likely. Any decision towards the one or other model requires, however, beforehand more knowledge regarding the historical landscape of Eastern Iran that is only recently beginning to emerge, as is demonstrated by the discovery of the Jiroft cemeteries and the definition of a Halilrud culture (Majidzadeh 2003; 2008).

#### **ISSUE 4: TIN FOR THE LORESTAN BRONZES AND THE FURTHER DEVELOPMENT OF BRONZE WORKING IN WESTERN IRAN**

Following the early adoption of tin bronze working in the EBA and its drop at the end of the 3<sup>rd</sup> millennium BC, the development of copper processing in Western Iran seems to become more stable throughout the 2<sup>nd</sup> millennium BC. Reliable data for Lorestan bronze working are sparse for the 2<sup>nd</sup> millennium BC, and it is only with the beginning of the Late Bronze/Early Iron Age that Lorestan bronze working reaches a new and original height with the so-called canonical Lorestan bronzes. Lorestan bronzes form a heterogeneous group of copper-base artefacts that have become known since the 1920s mostly through the art's market.<sup>19</sup> Only few derive from regular excavations, for example by Erich Schmidt in the 1930s in various places in Lorestan (Schmidt *et al.* 1989), and by a Danish team in Tappe Guran (Thrane *et al.* 2001). Most noteworthy are the results of the Belgian Lorestan Expedition directed by L. Vanden Berghe since 1965 (Overlaet 2003). From this it can be stated that Lorestan bronzes fall into different style groups of chronological significance, beginning roughly around 1300/1200 BC and running into the Iron Age.

In Susa is the regular production of artefacts from tin bronze attested since period V, roughly to be equated with the Ur III – Isin-Larsa period in Babylonia (Tallon 1987: 340-352). Susa is also one of the way stations for the tin trade since the Ur III period at least. In the material excavated at Susa, a deliberate choice of alloy varieties is evident: tin bronzes are preferably used for the production of weapons, such as shaft hole axes, indicating a raw material selection according to functionally desired properties (Malfoy and Menu 1987: 362; Tallon 1987: 352). Since it is generally thought that the metal used in Lorestan reaches there through trade via Mesopotamia or Elam (Haerinck and Overlaet

2004), it can be expected that the development of bronze working in Lorestan does not depart much from the development observed in Susa. This is, however, not fully the case: the material used in Susa and in Lorestan differs insofar as the copper used in Susa bronzes is less “pure” (Tallon 1987: 352), indicating a higher degree of recycling. A comparison of the isotope abundance ratios between Lorestan material and Mesopotamian artefacts indicates that the Lorestan objects had less varieties of raw material at their disposition (Begemann *et al.* 2008: 36). Both observations are strong arguments against a bronze production in the Lorestan highlands that would have been dependant on raw material procurement controlled by lowland authorities (Begemann *et al.* 2008) (vs. Haerinck and Overlaet 2004; Fleming *et al.* 2005). Instead, local dynamics of bronze production must be considered, and the discovery of possible raw material sources for the essential tin, and possibly copper, opens new venues of research there. First steps have been undertaken - in terms of element composition, the Deh Hossein deposit could have been a source supplying copper and tin to the production of Lorestan bronzes (Nezafati 2006; Begemann *et al.* 2008); isotopically speaking, Deh Hossein is equally a good (but not the sole) candidate for Lorestan bronzes.

## IN CONCLUSION

The ongoing discussion on the origins of tin for the bronze producing metalworkers of Mesopotamia

and Western Iran has received considerable impact through the availability of new data of original research – the discovery of new raw material deposits in Western Iran, and the analyses of excavated and well-dated materials from Lorestan. Considering the development of early copper processing in Western Asia in general, a period of experimentation in various materials available from locally confined sources of tin-copper, lead and possibly other materials can be stated to have occurred during the early 3<sup>rd</sup> millennium BC. This early start, however, does not lead to the formation of a stable industry. In the later Early Dynastic city states of Mesopotamia, elites seem to have taken over control of the traffic in such items through the newly developing maritime trade on the Persian Gulf, thereby possibly discouraging local industries from further developments. Susa begins only during the later part of the 3<sup>rd</sup> millennium to participate in the tin trade network, and in the 2<sup>nd</sup> millennium BC becomes one of its controlling nodes, as was Anshan further east.

With the Late Bronze Age, when an original tradition of bronze working develops in Lorestan with the so-called Lorestan bronzes, there seems to be a new reliance of the usage of local sources. It remains to be securely established whether the Deh Hossein deposit functioned as a raw material supplier to the these bronze workshops; in terms of element composition and isotope ratios that have so far been carried out only to a limited extent, it is in any case a good candidate.

## NOTES

- <sup>1</sup> Hauptmann and Pernicka 2004; Fleming *et al.* 2005; Fleming *et al.* 2006; Begemann *et al.* 2008; Begemann and Schmitt-Strecker 2009.
- <sup>2</sup> Canonized archaeological and textual evidence for the use of specific metals in ancient Southwestern Asia is presented in a clearly arranged way in Muhly 1973; Pernicka 1990; Joannes 1991; Muhly 1993; Joannes 1993-1997; Moorey 1994 and will not be repeated here.
- <sup>3</sup> See Weeks (2003: 165-195) for an up-to-date summary of the current state of archaeological research in Southwestern Asia.
- <sup>4</sup> According to the results of the research project “FMM – Early Metal in Mesopotamia”, by ED IIIa about 40 of the copper base objects in the Ur cemetery are produced from bronze (Müller-Karpe 1991: tab. 1, for summaries on this research, consult Stech 1999: tab. 3.1, a list of analyses of the FMM project is provided by J. Lutz in Hauptmann and Pernicka 2004).
- <sup>5</sup> The discover of rich graveyards on the Halil Rud („Jiroft“) in

Southeastern Iran has recently provided new fuel on the discussion for a location of this mystical land of Aratta, (see most recently Michalowski 1986, Potts 2004, see most recently Steinkeller 2007: 2-3 Footnote 4 with further references).

<sup>6</sup> For a location of Zabshali, see Potts (1999: 141-143).

<sup>7</sup> For an overview on the sources referring to Eastern tin, see Parzinger *et al.* (2003: 1-4); Potts 1994: 156 tab. 4.2.

<sup>8</sup> See Moorey (1982: 87), who claims that the significance assigned to the appearance of tin is indeed exaggerated.

<sup>9</sup> Among the canonized objects are specimen from Gawra VIII in Northern Iraq (Speiser 1935: 102; the object is not available for re-analysis, Stech and Pigott 1986: 43), Susa I and II (Cleuziou *et al.* 1982: 47-48 tab. C) and Sialk III5 (Halm 1939: 206-207). For a critical assessment of the evidence, see (Müller-Karpe 1989: 183-184; Weeks 2003: 174-178).

<sup>10</sup> Amongst these, a group of figural bronzes from Çüdeyde/Amuq (Braidwood and Braidwood 1960: 300-315 figs.

- 240-245; analyses 516-519) remains difficult to date, and a tin stamp seal from Mersin is equally not certified (following Müller-Karpe 1994: 13).
- <sup>11</sup> The open cast workings at Deh Hossein are currently dated to at least the 1st millennium BC, but an earlier beginning of its exploitation cannot be excluded.
- <sup>12</sup> One further group of metal items from early 3<sup>rd</sup> millennium BC contexts in the Hamrin that was qualified as "bronze" in the excavation report (Fujii 1981) and introduced as such into the literature (Van Lerberghe 1988), but was without element analysis, would then become much less exotic than before.
- <sup>13</sup> A 4<sup>th</sup> millennium BC date is claimed but not verified for a bronze from Mundigak III (Casal 1961: 37-48) in the Hilmand basin of western Afghanistan; the same applies to some unstratified objects from the Ghar-e Mar (Caley 1971). On the Pakistan side of Baluchistan, the oldest tin bronze artefacts date to the first half of the 3<sup>rd</sup> millennium BC (Ullah 1931; Asthana 1993; Besenval 1997; Possehl 1999).
- <sup>14</sup> For example, Tappe Sialk and Arisman are abandoned, and a surface survey in the Arisman hinterland revealed no alternative sites of the 3<sup>rd</sup> millennium BC (Chegini and Helwing in prep.). The sequence at Tal-e Malyan seems to be interrupted between the Banesh and the Kaftari phase as well; however, it seems as if this occupational gap is much less severe than previously thought, comp. Miller and Sumner (2003).
- <sup>15</sup> Large scale silting-up of plains may be partly responsible for the patterns of site discovery in these regions, comp. Schmidt and Fazeli (2007), Helwing *et al.* (in prep.).
- <sup>16</sup> Herrmann 1964; Beale 1973; Crawford 1974; Majidzadeh 1982; Stech and Pigott 1986.
- <sup>17</sup> Beale 1973; Alden 1982; see Lamberg-Karlovsky 2009 for a discussion of models regarding early trade.
- <sup>18</sup> Thornton *et al.* (2005) consider an Andronovo influence, Lamberg-Karlovsky (2003: 16) from the Namazga complex. Since the Zarafshan Valley sources seem to have been exploited only since the later 2<sup>nd</sup> millennium BC, and since they seem not to have supplied tin even to bronze producing cultures in the immediate neighbourhood, this model has been refuted by K. Kaniuth (2006: 170; 2007: 33).
- <sup>19</sup> Study of the so-called Lorestan bronzes is gravely hampered by the almost complete lack of reliable find contexts and through the existence of a considerable number of fakes and pastiche specimen. For a discussion of the problems related to the study of Lorestan bronzes, see Muscarella (2000).

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## CIRCULATION OF TIN IN GREATER IRAN FROM THE 4TH TO THE 1ST MILLENNIUM BC

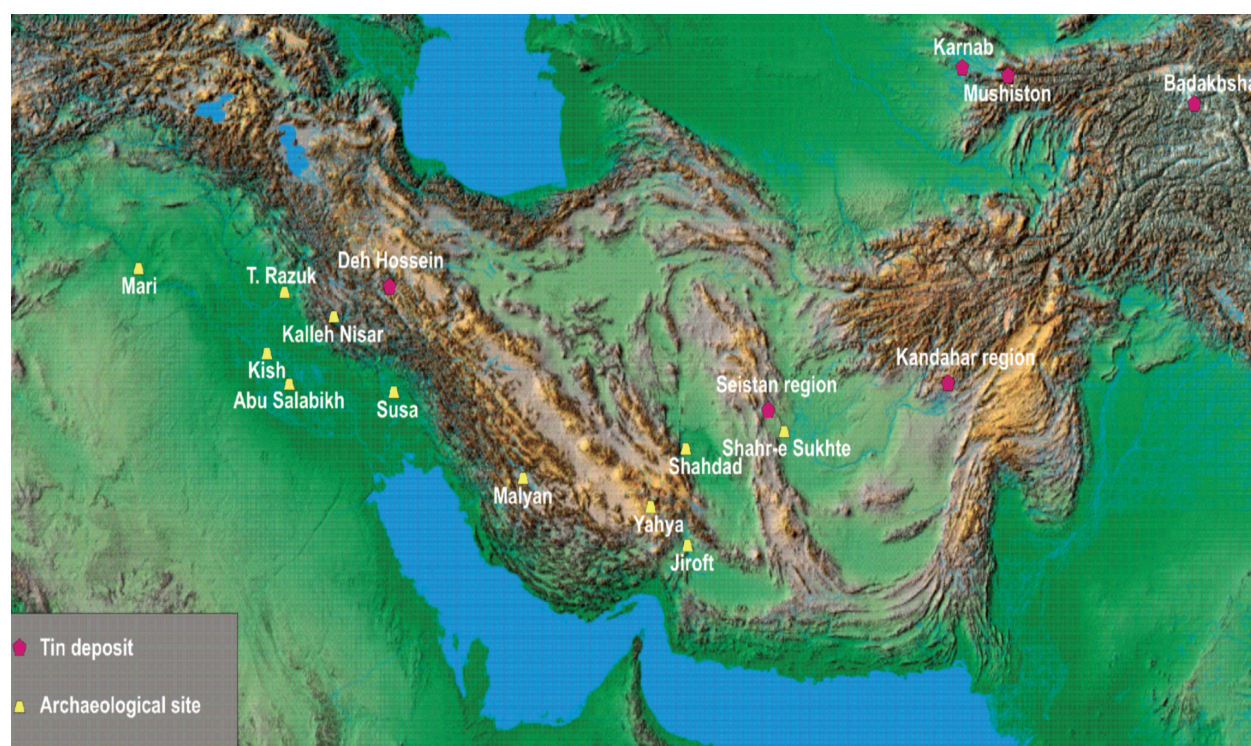


Fig. 1: Map showing tin deposits in the Deh Hossein area and sites discussed in the text.

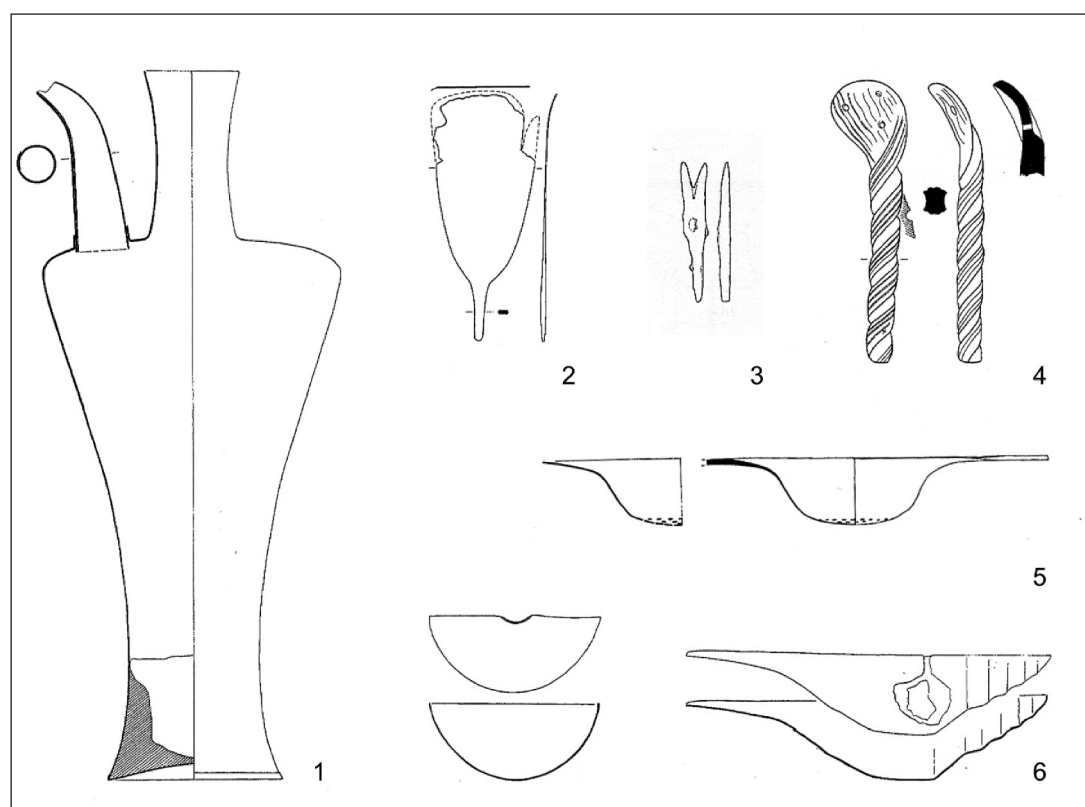


Fig. 2: Mesopotamian metal artefacts (first half of 3<sup>rd</sup> millennium BC) with > 1% tin (no. 2: razor, Kish, typologically dated to ED I/II; no. 3: point, Tell Razuk level IV, round building, ED I; no. 4: twisted rod, possibly braid of a statue, Tell Agrab, Shara temple, earlier building, ED II) and metal vessels with tin >10% (nos. 1, 6, Abu Salabikh, area A level V grave 2, ED II; no. 5, Abu Salabikh, area A level V, ED II); all drawings from Müller-Karpe 2004, no. 8, 10, 18, 45, 572, 723.